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Process optimization for development of bael enriched *Shrikhand*

PARAS PORWAL, RAJENDRA KUMAR PANDEY, BALASAHEB ANDHARE, SMITA SINGH AND REETA

The present study was undertaken for the development of bael enriched *Shrikhand* (BES). Response surface methodology (RSM) was used for the optimization of the process. Thirteen runs were performed with variables as bael pulp powder (BPP) and powdered sugar in ranges between 5-15 per cent and 25-35 per cent, respectively. The analysis was based over the effect on the responses such as colour, flavour, sweetness, body and texture and overall acceptability (OAA) scores. Optimized result was obtained with 15 per cent bael pulp powder and 25 per cent powdered sugar showing greater impacts on colour (8.29), flavour (8.52), sweetness (7.98), body and texture (8.14) and OAA (8.34). The desirability of the optimum condition was 0.89. The optimized product (BES) promises for nutritional advancement and positive health benefits.

Key Words : Bael, Response surface methodology, Colour, Sweetness

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INTRODUCTION

Aegle marmelos L. commonly known as bael (*Rutaceae* family) is used widely as medicinal plant with several biological activities (Lambole *et al.,* 2010). In India bael is a scared tree that is worshipped by the Hindus and the leaves of this tree is offered to Lord Shiva. Bael is a slow-growing sub-tropical plant indigenous to India and also grown in sub-continents and South-East Asia (Parmar and Kaushal, 1982; Sharma *et al.,* 2007 and Baliga *et al.,* 2011). The bioactive components present mainly in bael fruit are alkaloids, flavonoids, phenolics, tannins, coumarins, terpenoids (Parmar and Kaushal, 1982; Roy and Khurdiya, 1995; Suvimol and Pranee, 2008 and Maity *et al.,* 2009) steroids, phenol glycosides (Venkatesan *et al.,* 2009).

After the ripening of bael fruits, it could be eaten fresh or after drying them. During summers bael fruit is consumed widely in India as bael sharbat (sweetened drink) or bael panna (spicy drink) which gives soothing relief to thirst as well as provides instant energy. The leaves could also be eaten in form of green salad. Essential oil of the bael tree shows antibacterial activity, as it protects infection of gut due to bacteria.

Bael leaves have the capacity to reduce blood pressure, if taken regularly every morning which maintains the dilation of blood vessels (Parichha, 2004). In Ayurveda bael is considered as an excellent medicinal plant. The bael fruit as a whole, such as its leaves, fruits and bark have been useful in treating diabetes (Maity *et al*., 2009). Bael fruits are very much efficient in treating

MEMBERS OF RESEARCH FORUM

Author for correspondence :
BALASAHEB ANDHARE, Department of Animal Husbandry and Dairying, Institute of Agricultural Sciences, Banaras Hindu University, VARANASI (U.P.) INDIA
Email : andharebcshree@gmail.com

Associate Authors' :
RAJENDRA KUMAR PANDEY AND SMITA SINGH, Department of Animal Husbandry and Dairying, Institute of Agricultural Sciences, Banaras Hindu University, VARANASI (U.P.) INDIA
PARAS PORWAL AND REETA, Centre of Food Science and Technology, Banaras Hindu University, VARANASI (U.P.) INDIA

diarrhea and possess laxative property (Das and Das, 1995). The unripe fruits are found as an aid for digestion and stomach irritation. The aqueous and methanolic extracts of bael fruit fruit pulp have reduced the CCl_4-induced liver damage in mice (Baliga *et al*., 2011). The incorporation of bael pulp or powder into dairy products has not been explored extensively. Bael offers a lot of nutritional advancement which can be supplemented into the dairy products. Therefore, an innovative approach has been taken to develop bael enriched *Shrikhand* (BES).

METHODOLOGY

Fresh bael fruits were purchased from the local fruit market of Varanasi. Maltodextrin product, Maltrin 500® RM 1249 was obtained from Hi Media and Tricalcium phosphate was obtained from Pari Chemicals Mumbai. The standard culture was obtained from National Dairy Research Institute, Karnal, Haryana, India. The milk was procured from the Department of A.H. and Dairying, Banaras Hindu University, Varanasi, India.

Preparation of bael pulp powder :

The bael pulp powder was prepared at pilot plant scale spray dryer in the Centre of Food Science and Technology, Banaras Hindu University. Ripe bael fruits were washed thoroughly and then pulp was scooped out with seeds and fibres. Equal amount of water was then added with respect to the weight of the pulp. The mixture was properly kneaded and heated at 80°C for 1 min. Then, the pulp was blended for 8-10 min. after adding maltodextrin (2.48%) and tri-calcium phosphate (1.5%). The pulp was then fed into spray dryer with inlet air temperature 165°C, outlet air temperature 85°C with feed rate of 18-20 rpm. Bael powder was prepared for the development of bael enriched *Shrikhand* (BES) (Fig. A).

Preparation of bael enriched *Shrikhand* :

Experimental design :

RSM has been enormously applied in optimization processes in food industries (Pisecky, 1985; Arnous *et al*., 2001; Giusti and Wrolstad, 2001 and Klaypradit and Huang, 2008). Response surface methodology involves design of experiments (DOE), selection of levels of variables in experimental runs by fitting into mathematical models and then finally selecting variable levels by optimizing the response (Khuri and Cornell, 1987) was used in this study.

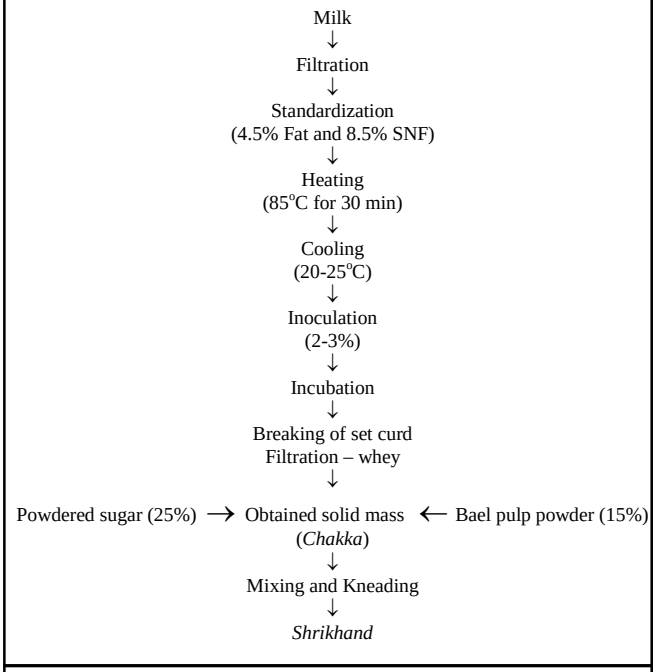

Fig. A : Flow-diagram for the manufacture of bael enriched *Shrikhand*

The variables taken for present work were concentration of bael pulp powder and powdered sugar in the range of 5-15 per cent and 25-35 per cent, respectively. A Central Composite Rotatable Design (CCRD) was used to design the experiments comprising of three independent variables (Table A). Thirteen trials were performed taking into account two factors *viz*., level of bael pulp powder and sugar. A good model must be significant and lack of fit must be insignificant. Co-efficient of determination (R^2) value must be close to 1. It explains the percentage of the variability of the result. The predicted R^2 value should be in agreement with the adjusted R^2. The responses used for the experiment are colour, flavour, sweetness, body and texture and overall acceptability and were used for quality evaluation for optimization of BES.

Data analysis :

The data analysis for the present investigation was done by using RSM by applying CCRD. Therefore, the data obtained was analyzed using second order polynomial equation (Eq. 1):

$$Y = \beta_o + \sum_{i=1}^{4}\beta_i X_i + \sum_{i=1}^{4}\beta_{ii} X_i^2 + \sum_{i=1}^{3}\sum_{j=i}^{4}\beta_{ij} X_i X_j \quad (1)$$

where,

Y = response variable

β_0, β_i, β_{ii} and β_{ij} = regression co-efficient

X_i, X_j and X_{ij} = coded independent variables

The design-expert software (9.0.6.2) was used for the optimization of the multiple responses. Thus, the responses obtained were analyzed to get the effect of various parameters on sensory properties of BES.

Sensory evaluation :

The BES samples were evaluated for their sensory characteristics such as colour, flavour, sweetness, body and texture and overall acceptability. This analysis was conducted by a panel of 7 semi-trained judges from Centre of Food Science and Technology, Banaras Hindu University, Varanasi, India. The judges were requested to record their perception of sensory analysis on a score card using hedonic scale ranging from 1 to 9, where 1was 'dislike extremely' and 9 was 'like extremely'. Sensory evaluation was performed at 25°C.

OBSERVATIONS AND ASSESSMENT

Response surface analysis was applied to the experimental data and response surface model (Eq.1) which was fitted with the sensory characteristic (colour, flavour, sweetness, body and texture) and OAA score. The statistical significance of the term was analyzed with the help of regression analysis and analysis of variance (ANOVA). Table 1 represents the experimented results for the development of BES and Table 2 represents the criteria and outputs of the optimization of the responses. Tables 3 and 4 represented the most desirable solution of the experiment and also the significant level of powder responses by using RSM.

Colour :

The effect of treatment parameters on the colour of BES is shown in Table1. Colour properties of BES were affected by both the bael pulp powder and sugar concentration. This can be explained by following relation:

$$\text{Colour} = 7.8 + 0.735 A - 0.213 B - 0.15 AB - 0.425 A^2 - 0.175 B^2 \quad (1)$$

where, A= Bael pulp powder; B= Sugar; A^2 = Bael pulp powder^2; B^2= Sugar^2

The range of colour was in between 6.0-8.4 (Table 2). The colour values showed the maximum effect on the sensory properties of *Shrikhand* which was obtained through the experimental design. The colour variable was mainly affected by the level of bael pulp powder (Table 1). As the sugar concentration increases, the colour properties decrease significantly. The bael pulp powder imparted a positive effect on the product (Fig. 1a).

Flavour :

The flavour is the aroma for attracting towards the product, especially *Shrikhand* in an aqueous solution. The flavour of BES ranged from 6.1- 8.6 (Table 2). The interactive effect of bael pulp powder and sugar

Table 1 : Experimental design for manufacturing of BES and response values for sensory parameters

Run	Factors		Response				
	Bael pulp powder %	Powdered sugar %	Colour	Flavour	Sweetness	Body and texture	Overall acceptability
1	15	35	7.6	7.6	8.4	8.5	8.7
2	5	25	6.5	6.6	6.9	7	7.2
3	10	30	7.6	7.6	7.2	7.4	7.5
4	10	37.07	7.2	6.3	7.8	7.9	8.1
5	10	30	7.85	7.8	7.3	7.4	7.6
6	10	22.92	7.7	7.4	7	7.1	7.3
7	10	30	7.86	7.5	7.2	7.6	7.5
8	10	30	7.85	7.9	7.4	7.5	7.7
9	15	25	8.4	8.6	8.2	8.4	8.6
10	5	35	6.3	6.6	7.5	7.6	7.8
11	17.07	30	7.9	8.3	8.2	8.3	8.5
12	10	30	7.84	7.7	7.5	7.2	7.4
13	2.92	30	6	6.1	6.8	6.9	7.1

concentration is explained in equation 3:

$$\textbf{Flavour} = 7.7 + 0.763^{*} A - 0.319^{*} B - 0.25^{*} AB - 0.168^{*} A^{2} - 0.343^{*} B^{2} \quad \ldots(3)$$

The flavour of *Shrikhand* is mainly affected by the concentration of bael pulp powder which is a positive interaction, whereas sugar had very little positive effect on it (Fig. 1B).

Sweetness :

The taste of BES is mainly due to the component sweetness which plays a major role in the proper development of the texture of the product. Eq. 4 represents the effect of bael pulp powder and sugar:

$$\textbf{Sweetness} = 7.32 + 0.522 * A + 0.241 * B - 0.1^{*} AB + 0.165 * A^{2} + 0.11 * B^{2}$$

The range of sweetness varied from 6.8-8.4 (Table 2). It is highly affected by the concentration of sugar and bael pulp powder (Fig. 1C).

Body and texture and overall acceptability :

The linear equations obtained by the RSA of the data showing the effect of A and B could be represented as follows:

$$\textbf{Body and texture} = 7.42 + 0.534 * A + 0.228^{*} B - 0.125^{*} AB + 0.171^{*} A^{2} + 0.121^{*} B^{2}$$

$$\textbf{Overall acceptability} = 7.54 + 0.534^{*} A + 0.228^{*} B - 0.125^{*} AB + 0.211^{*} A^{2} + 0.161^{*} B^{2}$$

The range for body and texture and OAA varied between 6.9-8.5 and 7.1-8.7, respectively (Table 2). These two parameters were highly affected with the increase of concentration of bael pulp powder and sugar also imparted highly positive effect (Fig. 1 D-E).

Table 2 : Constraints and criteria for optimization of BES

Name	Goal	Lower limit	Upper limit	Lower weight	Upper weight	Importance
A: Bael pulp powder (%)	Is in range	5	15	1	1	3
B: Sugar (%)	Is in range	25	35	1	1	3
Colour	Maximize	6	8.4	1	1	3
Flavour	Maximize	6.1	8.6	1	1	3
Sweetness	Is in range	6.8	8.4	1	1	3
Body and texture	Is in range	6.9	8.5	1	1	3
Overall acceptability	Maximize	7.1	8.7	1	1	3

Table 3 : Most desirable solution of the experiment

Sr. No.	Bael pulp powder	Powdered sugar	Colour	Flavour	Sweetness	Body and texture	Overall acceptability	Desirability	
1.	15	25	8.29	8.52	7.98	8.14	8.34	0.8967	Selected
2.	14.99	25.05	8.29	8.52	7.98	8.14	8.34	0.8962	
3.	14.99	25.09	8.29	8.52	7.97	8.14	8.33	0.8959	
4.	14.99	25.49	8.29	8.52	7.97	8.13	8.32	0.8925	
5.	14.79	25.00	8.29	8.49	7.94	8.10	8.29	0.8823	
6.	14.99	27.33	8.25	8.50	7.96	8.10	8.27	0.8722	
7.	14.60	25.00	8.29	8.46	7.90	8.06	8.25	0.8687	
8.	14.99	27.78	8.23	8.48	7.96	8.10	8.27	0.8662	

Table 4 : Significant level of responses using RSM

	p>F				
	Colour	Flavour	Sweetness	Body and texture	Overall acceptability
Model	3.18E-06	0.000205	0.001178	0.002116	0.001271
A: Bael pulp powder	4.07E-07	2.72E-05	0.000131	0.000229	0.00016
B: Powdered Sugar	0.001235	0.004978	0.010112	0.021154	0.016581
AB	0.035874	0.060823	0.340549	0.290912	0.265913
A^2	2.65E-05	0.087337	0.061418	0.077938	0.030885
B^2	0.005277	0.004892	0.164889	0.187356	0.078744
Lack of fit	0.428	0.136	0.110	0.117	0.053

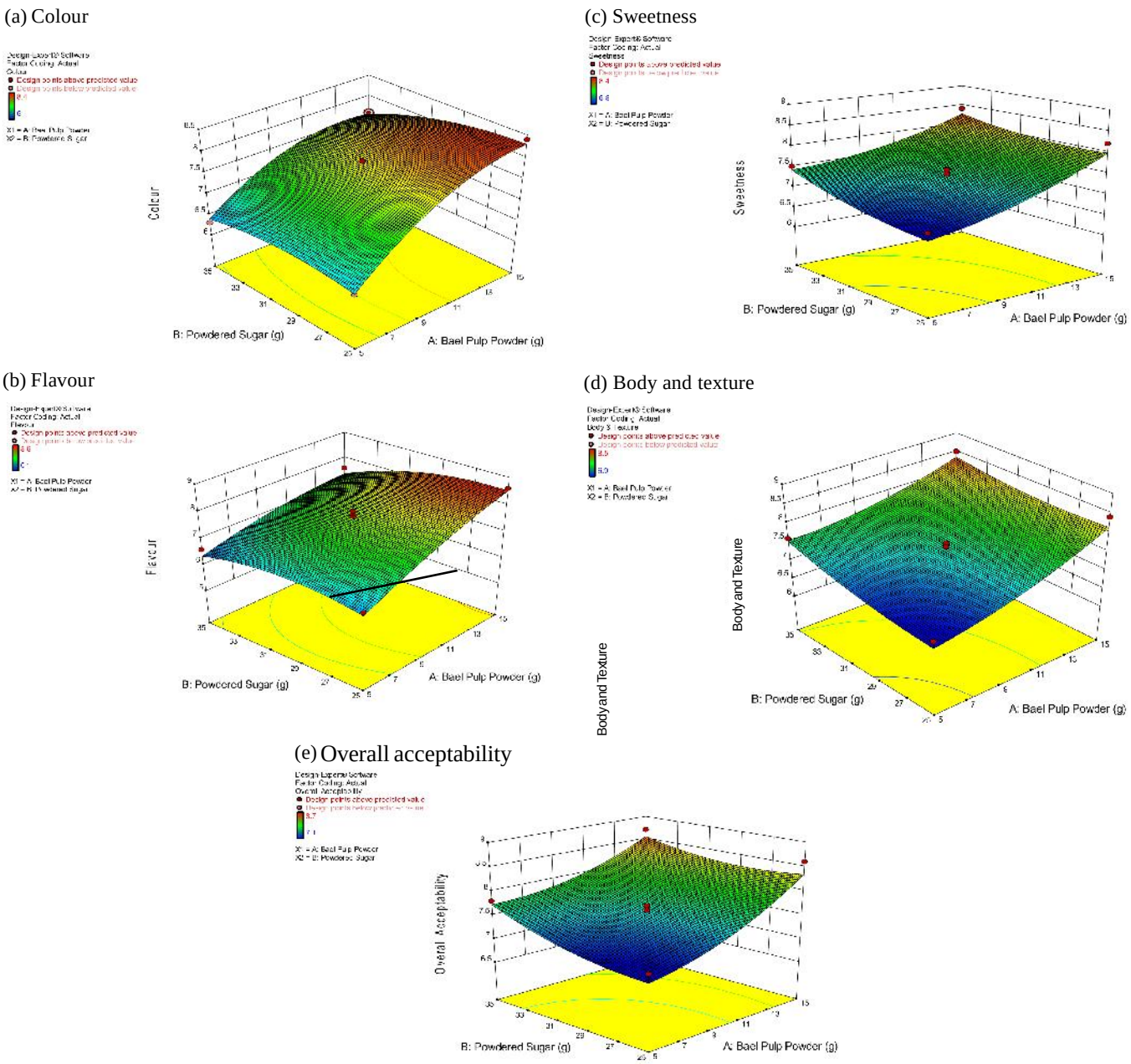

Fig. 1 : Effect of bael pulp powder and sugar concentration on different responses of bael enriched *Shrikhand*: (a) Colour (b) Flavour (c) Sweetness (d) Body and texture (e) Overall acceptability

Optimization of bael enriched *Shrikhand :*

The optimum conditions for the development of BES were based on the sensory parameters such as, colour, flavour, sweetness, body and texture and OAA. All these parameters were significantly affected by the level of bael pulp powder and sugar concentration.

For the development of BES, the results of the desirability 0.89 function, 15 per cent bael pulp powder and 25 per cent sugar concentration showed the best result in respect to the average score of colour, flavour, sweetness, body and texture and OAA which were 8.29, 8.52, 7.98, 8.14 and 8.34, respectively.

Conclusion :

Response surface methodology (RSM) was applied for conducting the trials of the experiment as well as for

optimization of the processing conditions (colour, flavour, sweetness, body and texture, OAA). CCRD was used for the study of the quality parameters of BES at various levels of application of bael pulp powder and sugar concentration. The models derived after the experiment for the parameters colour, flavour, sweetness, body and texture and OAA were statistically significant. The final concentration of the optimized product was 15 per cent bael pulp powder and 25 per cent powdered sugar. The developed bael enriched *Shrikhand* (BES) provides maximum sensory attributes which poses higher impact on the consumer acceptability of the product as well as ensures promising health benefits.

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